Discussion Draft 12-11-07:
Carbon Capture and Sequestration in Geological Formations

Demonstration of carbon capture and sequestration (CCS) in geological formations is a key opportunity for California to benefit from partnerships nationally and internationally. Broad commercial deployment of technology for CCS in geological formations faces significant challenges. On the other hand, it offers a potential opportunity for achieving long-term reductions in GHG emissions, especially on a national and international scale.

- *Time Frame:* demonstration projects can be in place by 2012, with potential for full commercialization by 2020

- *GHG Reduction Potential*: California has the technical potential to store 5.2 GT CO2 in oil and natural fields, and the capacity in deep saline formations may be one or two orders of magnitude greater.[i] The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS has the potential to abate CO_2 emissions by between 15-55 percent of the cumulative mitigation effort needed by 2100 on the international scale.

- *Ease of Implementation:* Difficult

- *Co-benefits / Mitigation Requirements:* Demonstration of this technology may facilitate large benefits if it results in commercial application in coal-dependent areas outside of California. The energy required for CCS would require additional fuel combustion (which could be offset to the extent that CO_2 injection displaces steam for oil production). Some technologies to capture CO_2 also reduce criteria pollutants like NOx and SO_2. If fuel combustion increases, without increased emissions control, emission decreases elsewhere will be required in areas that fail to meet clean air standards. Leakage risk must be assessed at a general level for the technology and for specific potential sites.

- *Responsible Parties:* federal and state governments and agencies and the private sector

Problem: Gelogical CCS refers to the separation (or capture) of CO_2 from industrial and power generation sources and then the transportation to storage locations for long term isolation from the atmosphere. (This chapter of the report does not include biological storage in the agricultural and forestry sectors). Many component technologies for CCS have already been developed, but both the size and number of demonstration projects are very small with respect to the scale necessary to mitigate significant future CO_2 emissions. Commercialization of CCS technologies will require a willingness to bear the initial high cost and potential risks of first-generation systems and continued technical advances to build up the required infrastructure. The low end of cost estimates ranges tend to start at $25 per ton or more for capture and compression. Cost estimates vary, at least in part because the technology has not been demonstrated. Part of that cost can potentially be recovered if CO_2 is used for Enhanced Oil Recovery (2005 dollars), while transportation and injection is an additional cost.[ii]

In addition, there is relatively little experience to date at the federal or state level in combining CO_2 capture, transport, and storage into a fully integrated CCS system. Furthermore, regulatory uncertainties and legal issues regarding property rights and liability are significant barriers for CCS that must be resolved before the CCS could play any major role in meeting AB 32's GHG emission reduction goals. ~~For example, it is not clear whether underground injection of CO_2 is under federal or state agency jurisdiction.~~ Access and liability issues present another challenge. Different states have different laws regarding land rights, pore rights, and mineral rights; therefore, developers of CCS projects face varying state regulations pertaining to underground storage. More importantly, the long term responsibility and liability associated with the CCS projects must be clearly defined. Monitoring techniques and standards that need to be approved at various governmental levels, and then accepted by the insurance industry, have yet to be put in place. The issue of long-term liability for gradual or catastrophic future leakage is clearly hampering demonstration projects.

Possible Solution: California should continue to participate in partnerships such as WESTCARB to advance technology assessments and demonstrations. Key priorities identified by WESTCARB for upcoming pilot projects in California and other western states include:

- Testing technologies
- Assessing capacity
- Defining costs
- Assessing leakage risks
- Gauging public acceptance
- Testing regulatory requirements
- Validating monitoring methods.[iii]

The support of federal funding is especially important since CCS has even greater importance nationally than in California. International partnerships should be leveraged to spur efforts to develop lower cost carbon capture technologies, as well as storage research to the extent that there are common challenges and solutions (most likely for deep saline formations).

The state should also work with the federal government to address the legal, regulatory, and safety barriers and issues associated with CCS. One important issue is the development of a legal framework to address long-term liability associated with carbon sequestration. [iv] Private insurers may lack a framework for evaluating CCS projects, especially multi-generational liability. The federal and state government could play a productive role, while carefully balancing the interests of taxpayers and the need to maximize incentives for careful carbon management decisions by the private sector.

Currently, potential pilot projects are evaluated on a case-by-case basis under general Underground Injection Control permitting requirements. The California Department of

Oil and Gas Resources (DOGR) has delegation from US EPA for oil & gas fields (US EPA retains oversight). Federal US EPA has responsibility for deep saline formations and DOGR is also developing their own regulations for deep saline formations (and can work with US EPA to request lead permitting responsibility once that process is completed). Drawing on the experience learned from the permitting process for pilot projects to develop standards and guidelines at the state and federal level may also help CCS project developers navigate the permitting process.[v]

Unlike many efficiency measures, CCS is unlikely to bring a positive economic return under even the most optimistic scenarios currently foreseeable. In addition to these efforts, a clear and reliable price signal (as discussed elsewhere in this report) and/or performance standards such as AB 1386 will be necessary to commercialize this technology.

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[i] Quarterly Report, West Coast Regional Carbon Sequestration Partnership California Energy Commission, May 2005, page 8.

[ii] Quarterly Report, West Coast Regional Carbon Sequestration Partnership California Energy Commission, May 2005, page 15; Reducing US Greenhouse Gas Emissions: How Much as What Cost ? December 2007 page 59; Carbon Dioxide Capture and Geologic Storage 2007 page 33.

[iii] WESTCARB Regional Partnership Phase II: Providing Underpinnings for Deployment Larry Myer WESTCARB Technical Director, California Energy Commission, May 11, 2006

[iv] The state of Texas, where CO_2 is used routinely for increased oil & gas production, has passed a law accepting liability for a potential "Future Gen" project with CCS that Texas is hoping will be located in Texas.

[v] Personal communication from George Robin, US EPA Pacific Southwest Region, Water Division, Underground Injection Control, to Ed Pike December 5 2007.